

A new species of electric ray, *Narcine leoparda*, from the tropical eastern Pacific Ocean (Chondrichthyes: Torpediniformes: Narcinidae)

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Abstract.—A new species of electric ray, *Narcine leoparda*, is described from 17 specimens collected from four localities off the southern Pacific coast of Colombia, in shallow waters up to 35 m in depth. *Narcine leoparda* is distinguished from all other species of *Narcine* by its unique dorsal color pattern, composed of numerous small white to creamy-white spots and/or ocelli that are also present on dorsal and caudal fins, over a brown to reddish-brown background. Other characters that in combination further distinguish this new species include broadly rounded tooth bands that are sub-equal in width, tail length shorter than or sub-equal to disc width or length, spiracles devoid of external papillae, lateral tail fold originating under first dorsal fin base, and second dorsal fin usually slightly greater than first in both height and length of base. *Narcine leoparda* is similar in overall aspect and proportional measurements to *N. vermiculatus*, also from the tropical eastern Pacific (Gulf of California south to Costa Rica), but dorsal coloration easily distinguishes individuals of all sizes of both species, which do not co-occur. *Narcine leoparda* is the third valid species of *Narcine* from the eastern Pacific Ocean.

Species of the electric ray genus *Narcine* Henle, 1834 are small to medium-sized batoids that are more diverse in the tropical Indo-west Pacific region, where at least 15 valid species are known to occur (Carvalho et al. 2000). In contrast, only two previously described species of *Narcine* are here accepted as valid from the eastern Pacific Ocean: *Narcine entemedor* Jordan & Starks, 1895 and *Narcine vermiculatus* Breder, 1928. *Narcine entemedor* has erroneously been considered a junior synonym of *N. brasiliensis* (= *N. bancroftii*) by many recent authors (Bussing & López S. 1994, Castro-Aguirre & Pérez 1996), who have followed the otherwise excellent revision of Bigelow & Schroeder (1953) (cf. Beebe & Tee-Van 1941, McEachran 1995). *Narcine schmitti* Hildebrand, 1948, described from a single specimen from the Gulf of California, has previously been considered to be a valid species as well (Bigelow & Schroe-

der 1953, Castro-Aguirre & Pérez 1996), but was synonymized with *N. vermiculatus* by Carvalho (1999a), who revised the genus. A third and very distinctive species of *Narcine* has been collected from shallow waters off the Pacific coast of southern Colombia, and is described below as a new species.

Methods

Measurements on the holotype and 12 paratypes were taken with electronic calipers in a straight line, point-to-point to the nearest tenth of a millimeter. Large specimens requiring measurements of 150 mm or more were measured with the aid of a steel ruler or tape measure, and are expressed to the nearest millimeter. All measurements are presented in Table 1, and are expressed as proportions of total length, following Carvalho (1999a). Measurements of

electric rays are subject to discrepancy due to preservational variations, and should be interpreted with caution if specimens appear damaged or distorted (Fechhelm & McEachran 1984, Carvalho 1999b). Measurements are as follows: total length (TL, from tip of snout to posteriormost tip at mid-caudal height; in millimeters, independent variable from which all proportional values are derived); disc width (DW, across widest aspect of disc, usually close to level of third gill openings); disc length (DL, from anterior snout region to greatest disc length, lateral to pectoral axil); preorbital snout length (PBS, from in between anterior level of eyes to anterior margin of snout); preoral snout length (POS, from top of lower tooth band to anterior margin of snout); prenasal snout length (PNS, from in between anterior level of nostrils to anterior snout margin); snout to greatest disc width (SDW, from anterior snout to level of greatest disc width, measured over mid-disc); interorbital distance (IOD, straight distance between inner margins of orbits); eye length (EL, between anterior and posterior margins of eye); interspiracular distance (ISD, between inner margins of spiracles); spiracle length (SPL, greatest antero-posterior distance through spiracle); spiracle width (SPW, greatest lateral extent of spiracle); mouth width (MW, distance between mouth corners, measured between junction of upper and lower labial cartilages on each side of jaws); upper tooth band width (UTB, width of exposed upper tooth band in between posterior margin of lips [formed by the upper labial cartilages], close to mouth opening); lower tooth band width (LTB, width of exposed lower tooth band at anterior margin of lips [formed by the lower labial cartilages], close to mouth opening); nasal curtain width (NCW, width of nasal curtain at greatest width below nostrils); nasal curtain length (NCL, length of nasal curtain from level of anterior margin of nostrils to posterior-most point at mid-line of nasal curtain); distance between nostrils (DBN, between inner margins of nos-

trils); distance between first gill openings (FGO, between inner margins of first pair of gill openings); distance between last gill openings (LGO, between inner margins of last pair of gill openings); branchial basket length (BBL, between first and last gill openings); pelvic fin length (PFL, length of pelvic fin from insertion to posterior-most point, measured ventrally); pelvic fin width (PFW, distance between outer-most corners of pelvic fins, from tip to tip, measured ventrally); anterior margin of pelvic fin (AMP, greatest extent from insertion to outer-most corner of pelvic fin); posterior margin of pelvic fin (PMP, greatest extent from outer-most corner to posterior-most point of pelvic fin); tail width (TW, extent across base of tail at greatest width, measured dorsally); height of first dorsal fin (HFD, distance from greatest height at apex to mid-base of first dorsal fin); length of first dorsal fin (LFD, greatest length of base of first dorsal fin); height of second dorsal fin (HSD, distance from greatest height at apex to mid-base of second dorsal fin); length of second dorsal fin (LSD, greatest length of base of second dorsal fin); length of dorsal lobe of caudal fin (LDC, distance from origin on dorsal caudal peduncle to posterior-most tip of caudal fin); length of ventral lobe of caudal fin (LVC, distance from origin on ventral caudal peduncle to posterior-most tip of caudal fin); height of dorsal lobe of caudal fin (HDC, measured vertically from uppermost tip of caudal fin apex to base of dorsal lobe on tail); height of ventral lobe of caudal fin (HVC, measured vertically from lower-most tip of caudal fin to base of ventral lobe on tail); height of caudal fin (HC, greatest distance between dorsal and caudal fin margins, does not equal $HDC + HVC$); distance between dorsal fins (DBD, distance between posterior tip of first dorsal fin base and anterior tip of second dorsal fin base); distance between second dorsal and caudal fins (SDC, from posterior tip of second dorsal fin to dorsal origin of caudal peduncle); snout to cloaca length (SCL, distance between anterior snout margin to or-

igin of cloaca); cloaca to caudal fin length (CLC, distance from posterior tip of cloaca to posterior margin of caudal fin, equals tail length); snout to first dorsal fin length (SFD, distance from anterior margin of snout to origin of first dorsal fin); electric organ length (EOL, from anterior margin to posterior margin of electric organ, measured ventrally); electric organ width (EOW, greatest width of electric organ at its mid-length, close to level of third gill slit, measured ventrally); clasper length (CL, from posterior tip of cloaca to distal-most tip of clasper).

Counts were taken from radiographs, and are summarized in Table 2. Usage of meristic characters also follows Carvalho (1999a). Counts include: propterygium radials (PRO); mesopterygium radials (MES); metapterygium radials (MET); total pectoral radials (TPR = PRO + MES + MET); pelvic radials (PVR); first dorsal fin radials (FDR); second dorsal fin radials (SDR); dorsal lobe of caudal fin radials (DCR); ventral lobe of caudal fin radials (VCR, includes radial situated in between dorsal and ventral aspects of caudal fin); total caudal radials (TCR = DCR + VCR); exposed vertical tooth rows on upper tooth band (UTR, corresponds to tooth rows visible externally on upper jaw when mouth is closed); exposed vertical tooth rows on lower tooth band (LTR, corresponds to tooth rows visible externally on lower jaw when mouth is closed); trunk vertebral centra (TC, from first whole distinguishable centrum in synarcual to anterior margin of pelvic girdle, further explained below); pre-caudal vertebral centra (PC, centra from anterior margin of pelvic girdle to origin of upper lobe of caudal fin); caudal vertebral centra (CC, from first centrum in caudal fin to last distinguishable centrum); total vertebral centra (TV = TC + PC + CC); ribs (R, elongated pleural ribs articulating with paired hemal spines, located posteriorly on disc dorsal to pelvic girdle area). The division of the vertebral column into trunk and pre-caudal centra uses the pelvic girdle

as a landmark because it was not always possible to discern monospondylous to diplospondylous transitions from radiographs. Radial elements of the pectoral and dorsal fins that are joined at base were counted as two separate elements. Tooth counts were taken under stereomicroscope and follow the method outlined in Stehmann (1978), where rows are counted following a cranial-caudal orientation. Only exposed tooth rows were counted, i.e., rows visible on tooth bands when mouth is closed (dissection is necessary to count internal tooth rows because of the strong labial cartilages immediately lateral to the tooth bands, and dissection was not always possible). Tooth counts are expressed as fractions (numerator designates the number of exposed rows on the upper jaws, and the denominator indicates the same on the lower jaws).

Comparative material of all species of *Narcine* was used for the present study, and is listed in Carvalho (1999a). Institutional abbreviations follow Leviton et al. (1985). The term "preadult" is used to indicate specimens that are not sexually mature (or "adult"). Clasper rigidity was used as an indicator of sexual maturity for males, because gonadal maturity usually closely follows clasper calcification.

Order Torpediniformes Berg, 1940
 Family Narcinidae Gill, 1862
 Genus *Narcine* Henle, 1834
Narcine leoparda, new species
 Figs. 1–4; Tables 1–2

Holotype.—USNM 222200, 277 mm TL adult female, south of Buenaventura, Colombia, 02°56'N, 078°07'W, 0–16.6 m (0–5 fathoms), R/V *Cacique* (LK 69–29, L. Knapp), 20. ix. 1969. (Fig. 1).

Paratypes.—USNM 222198 (7 specimens, adult and preadult), 200 mm TL female (with two pups), 174 mm TL male, 174 mm TL female, 110 mm TL female (cleared and stained), one dissected specimen (no size data available, but probably close to 150 mm TL), south of Buenaven-



Fig. 1. Dorsal (A) and ventral (B) view of holotype of *Narcine leoparda*, n. sp. (USNM 222200, 277 mm TL adult female, from south of Buenaventura, Colombia, 02°56'N, 078°07'W, 0–16.6 m).

tura, Colombia, 03°14'N, 077°33'W, 5–7 m, sta. 357, FAO, 25. I. 1969; USNM 222199 (6, all preadult), 168 mm TL female, 163 mm TL female, 146 mm TL female, 130

mm TL female, 127 mm TL female, 86 mm TL male, south of Tumaco (Punta Manglares), Colombia, 01°39'N, 079°02'30"W–01°37'30"N, 079°02'00"W, 33.3 m (10 fath-

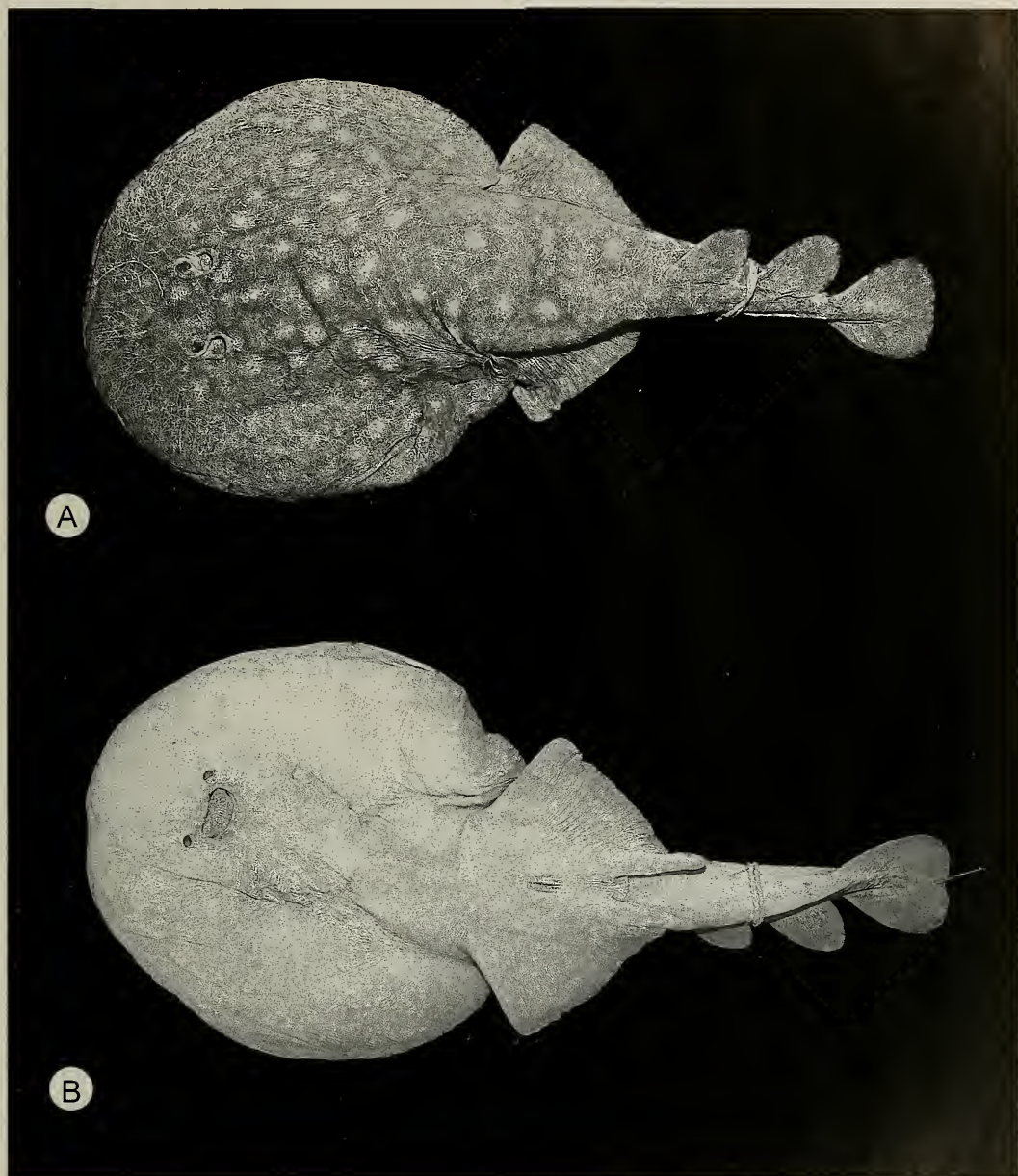


Fig. 2. Dorsal (A) and ventral (B) view of paratype of *Narcine leoparda*, n. sp. (USNM 235919, 206 mm TL adult male, south of Tumaco, Colombia, $01^{\circ}39'N$, $079^{\circ}02'30''W$ – $01^{\circ}37'30''N$, $079^{\circ}02'00''W$, 33.3 m). Caudal fin is downturned in (B).

oms), sta. 343 (1:55 p.m.–2:55 p.m.), R/V *Inderena* (LK 70-12, L. Knapp), 27. x. 1970; USNM 222498, 272 mm TL adult female (same data as holotype); USNM 222500, 230 mm TL adult male, $01^{\circ}35'05''N$, $079^{\circ}03'00''W$ – $01^{\circ}37'00''N$, $079^{\circ}04'00''W$,

south of Tumaco (Punta Manglares), Colombia, 9.15 m, sta. 342, R/V *Inderena*, (LK 70-11, L. Knapp), 27. x. 1970; USNM 235519, 206 mm TL adult male, data as for USNM 222199.

Diagnosis.—A species of *Narcine* distin-

guished from all others by its unique dorsal coloration composed of numerous small white to creamy-white spots and/or ocelli on disc and dorsal and caudal fins, over a reddish-brown or brown background. Additional characters that in combination diagnose this new species include: tail length shorter than disc width or length, upper and lower external tooth bands subequal in width, spiracles with smooth rims devoid of external papillae, second dorsal fin usually slightly larger than first in both height and length of base, and lateral tail folds originating under level of first dorsal fin base.

Description.—Measurements and counts are summarized in Tables 1 and 2, respectively.

External morphology: Disc rounded to somewhat oval, generally about as wide as long. Disc width is somewhat more variable than disc length (see standard deviations in Table 1). Disc overlaps origin of pelvic fins only slightly, and with a very small free lobe posteriorly where it contacts sides of trunk. Greatest width of disc is just posterior to its mid-length, but somewhat variable in specimens. Snout broadly rounded anteriorly. Preorbital snout corresponds to about one-third in disc length. Electric organ originating just anterior to level of eyes dorsally and at level of nostrils ventrally. On ventral side, electric organs extend to beyond level of last gill-slit; electric organs difficult to discern in dorsal view. Gill-slits small, only slightly curved and in more or less straight line from first to last gill slit. Distance between last gill-slits generally less than branchial basket length. Spiracles and eyes adjacent, without a distinctive separation. Spiracles with somewhat developed rims devoid of papillae, circular to oval, and usually slightly longer than wide. Eyes relatively small, about as long as spiracles.

Nasal curtain wider than long (Fig. 3C), with more or less straight posterior margin, but faintly developed central lobe present in some specimens. Nostrils small and circular; distance between nostrils slightly greater than nasal curtain width at posterior mar-

gin. Prenasal snout length generally less than preorbital snout length. Mouth about as wide as distance between nostrils. Upper and lower tooth bands more or less equal in width and both circular in outline. Teeth in 12/8–16/12 exposed rows in specimens about 175 mm total length or larger, but a 146 mm total length female has 11/13 exposed teeth rows. Teeth relatively small, set in quincunx arrangement and with single, sharp cusp, even on small specimens (e.g., 146 mm TL specimen); inner rows with very sharp teeth. Crowns wider-than-long at bases; tooth bases roughly sub-circular.

Posterior lobes of pelvics more or less straight, with only a small free lobe where they contact claspers or lateral aspect of trunk (in females). Lateral corners of pelvics blunt, not acute. Pelvics generally extend from underneath posterior disc region to underneath beginning of first dorsal fin base. Claspers of larger males extend posteriorly to close to posterior aspect of first dorsal fin base, but do not project greatly beyond pelvic fins. Tail relatively short as measured from cloaca, shorter than snout to cloaca length, and much shorter than disc width and length. Tail sub-circular in cross section; its width at base moderately broad and somewhat variable. Lateral tail fold extending as a thin keel in a straight line laterally on tail, from level of mid- to posterior first dorsal fin base to lateral aspect of caudal peduncle. Second dorsal fin only slightly taller than first dorsal fin, and with a slightly longer base. Dorsal fins similar in shape, and with a small free lobe posteriorly (Fig. 3B). Caudal fin with angular apex, relatively tall and not elongated, and with more or less straight posterior margin. Length of dorsal and ventral lobes of caudal about equal, but dorsal lobe slightly taller than ventral lobe. Distance between second dorsal and caudal fins generally slightly greater than distance between dorsal fins.

Sensory pores indistinct, few in number, and scattered on ventral snout area and along margins of electric organs both dorsally (hyomandibular canal) and ventrally

Table 1.—Morphometric comparisons for *Narcine leoparda*, n. sp. *n* is number of specimens from which means and standard deviations (SD) were calculated and include specimens greater than 110 mm TL. See Methods section for abbreviations. Holotype: USNM 222200; Paratypes: USNM 222198, USNM 222199, USNM 222498, USNM 222500, USNM 235519.

	Holotype	Paratypes	<i>n</i>	<i>x</i>	<i>SD</i>
TL (mm)	277.0	110.0–272.0	13	—	—
DW (%)	48.7	46.6–57.3	13	52.0	3.5
DL (%)	53.1	50.0–58.2	13	53.4	2.3
PBS (%)	13.3	12.7–15.7	13	14.6	1.0
POS (%)	14.7	14.5–17.5	13	15.5	1.1
PNS (%)	12.3	12.0–14.4	13	13.0	0.9
SDW (%)	31.8	21.1–41.0	13	32.3	3.0
IOD (%)	6.4	6.0–8.5	13	7.4	0.8
EL (%)	2.3	1.8–3.0	13	2.4	0.4
ISD (%)	6.0	5.8–8.5	13	7.1	0.8
SPL (%)	2.2	2.1–3.0	13	2.4	0.3
SPW (%)	1.6	1.8–2.7	13	2.1	0.3
MW (%)	5.3	5.3–6.7	13	5.9	0.4
UTB (%)	2.3	2.3–3.2	13	2.6	0.3
LTB (%)	2.1	1.9–2.8	13	2.3	0.3
NCW (%)	5.0	5.1–6.6	8	5.7	0.7
NCL (%)	1.5	1.0–2.4	11	1.8	0.4
DBN (%)	5.6	5.5–7.3	13	6.1	0.5
FGO (%)	12.3	11.5–14.5	13	13.3	0.8
LGO (%)	6.9	5.9–9.5	13	7.1	0.9
BBL (%)	9.1	7.2–11.0	13	9.8	1.0
PFL (%)	19.9	17.8–23.5	13	20.7	1.9
PFW (%)	26.7	28.7–36.8	13	33.5	3.0
AMP (%)	12.7	11.3–14.2	13	12.4	0.8
PMP (%)	19.0	15.5–23.2	13	19.5	2.6
TW (%)	15.4	16.6–21.6	13	18.9	1.8
HFD (%)	7.8	6.8–9.3	13	8.2	0.8
LFD (%)	6.3	4.5–7.6	13	5.9	0.7
HSD (%)	8.8	7.5–9.9	13	8.8	0.6
LSD (%)	6.1	5.5–7.3	13	6.2	0.5
LDC (%)	11.8	11.8–13.1	13	12.3	0.4
LVC (%)	11.0	11.6–14.1	13	12.7	1.0
HDC (%)	4.7	3.2–5.0	13	4.4	0.5
HVC (%)	3.1	2.2–4.7	13	3.7	0.8
HC (%)	9.2	7.5–12.5	13	10.3	1.3
DBD (%)	2.5	2.2–3.4	13	2.6	0.4
SDC (%)	3.2	2.5–3.9	13	3.3	0.5
SCL (%)	53.1	50.0–54.8	13	52.6	1.3
CLC (%)	43.3	39.7–47.0	13	42.6	2.0
SFD (%)	65.0	65.4–70.1	13	68.0	1.6
EOL (%)	24.2	22.8–29.2	13	25.0	1.9
EOW (%)	10.1	9.8–12.1	13	10.7	0.7
CL (%)	—	15.7–17.0	3	16.2	0.7

(ampullary pores only). Few sensory pores dorsally in more or less straight rows on snout region. Pores of lateral canal on lateral aspect of tail running dorsal to lateral tail fold, apparently in a straight line and terminating on lateral aspect of caudal base.

Lateral tail fold pores are very scattered and not numerous. Pores on ventral snout area in more or less parallel antero-posterior rows, not extending posteriorly beyond level of nostrils.

Coloration: In preservative, dorsal back-

Table 2.—Meristic features of *Narcine leoparda*, n. sp. A) USNM 222200 (holotype); B) USNM 222500; C) USNM 222498; D) USNM 235519; E) USNM 222199; F) USNM 222199. B–F represent paratypes. Dashes represent counts not available in radiographs. See Methods section for abbreviations.

	A	B	C	D	E	F	Range
TL (mm)	277	230	272	206	163	168	163–277
PRO	18	17	17	17	—	18	17–18
MES	6	6	6	5	—	6	5–6
MET	11	10	12	9	—	—	9–12
TPR	35	33	35	31	—	—	31–35
PVR	19	17	19	19	20	19	17–20
FDR	8	8	6	8	—	8	6–8
SDR	10	9	7	10	10	10	7–10
DCR	26	17	23	21	—	—	17–26
VCR	27	22	24	25	—	—	22–27
TCR	53	39	47	46	—	—	39–53
UTR	16	15	16	12	13	11	11–16
LTR	9	12	13	9	10	8	8–13
TC	28	24	24	26	28	24	24–28
PC	59	59	59	59	60	59	59–60
CC	24	20	23	22	24	23	20–24
TV	111	103	106	107	112	106	103–112
R	8	8	7	8	7	8	7–8

ground coloration composed of a light, dark, reddish- or purplish-brown background, with white to creamy-white spots or ocelli covering most of disc region posterior to eyes, and extending posteriorly over tail. Dorsal and caudal fins also with small white spots on all specimens. Spots and ocelli generally not fused into irregularly shaped blotches, especially in smaller specimens where spots are clearly separated from each other (Fig. 4). Spots are round to slightly oval, varying in definition from sharply defined to somewhat fuzzy. Spots may be present between eyes, especially in smaller specimens, or anterior to eyes over dorsal snout region. Smaller specimens with spots ranging in size from small (about equivalent to diameter of eyes and spiracles) to slightly larger (about twice eye-diameter). Larger specimens have more variable coloration, with ocelli closely (holotype; Fig. 1) or loosely packed together (paratype USNM 235919; Fig. 2). Ocelli composed of central white to creamy-white spot, surrounded by ring of darker brown. Dorsal coloration mostly restricted to background coloration in two large paratypes

(USNM 222498 [Fig. 3A] and USNM 222500), but remnants of ocelli are visible, and small white spots remain present on dorsal and caudal fins. Ventral coloration uniform creamy-white, but some larger adults may have the posterior disc and pelvic fins outlined in light brown.

Skeletal features: Examination of skeletonized and cleared and stained specimens (both from USNM 222198) reveal that *Narcine leoparda* shares with other species of *Narcine*, including the type-species *N. brasiliensis* (von Olfers, 1831), the following features indicative of generic monophyly (Carvalho 1999a): fused hypobranchial plates with sinuous external margins articulating with ceratobranchials 2–4, slender posterior projection of the heart-shaped basibranchial copula, separation of ceratohyal and “hypobranchial 1” by a small gap, and presence of a separate facio-palatine foramen in the orbit. In general aspects, the skeletal anatomy of *Narcine leoparda* is similar to that of *N. brasiliensis*, with relatively wide and proximally branched antorbital cartilages that bear numerous digitiform projections distally. Lateral rostral

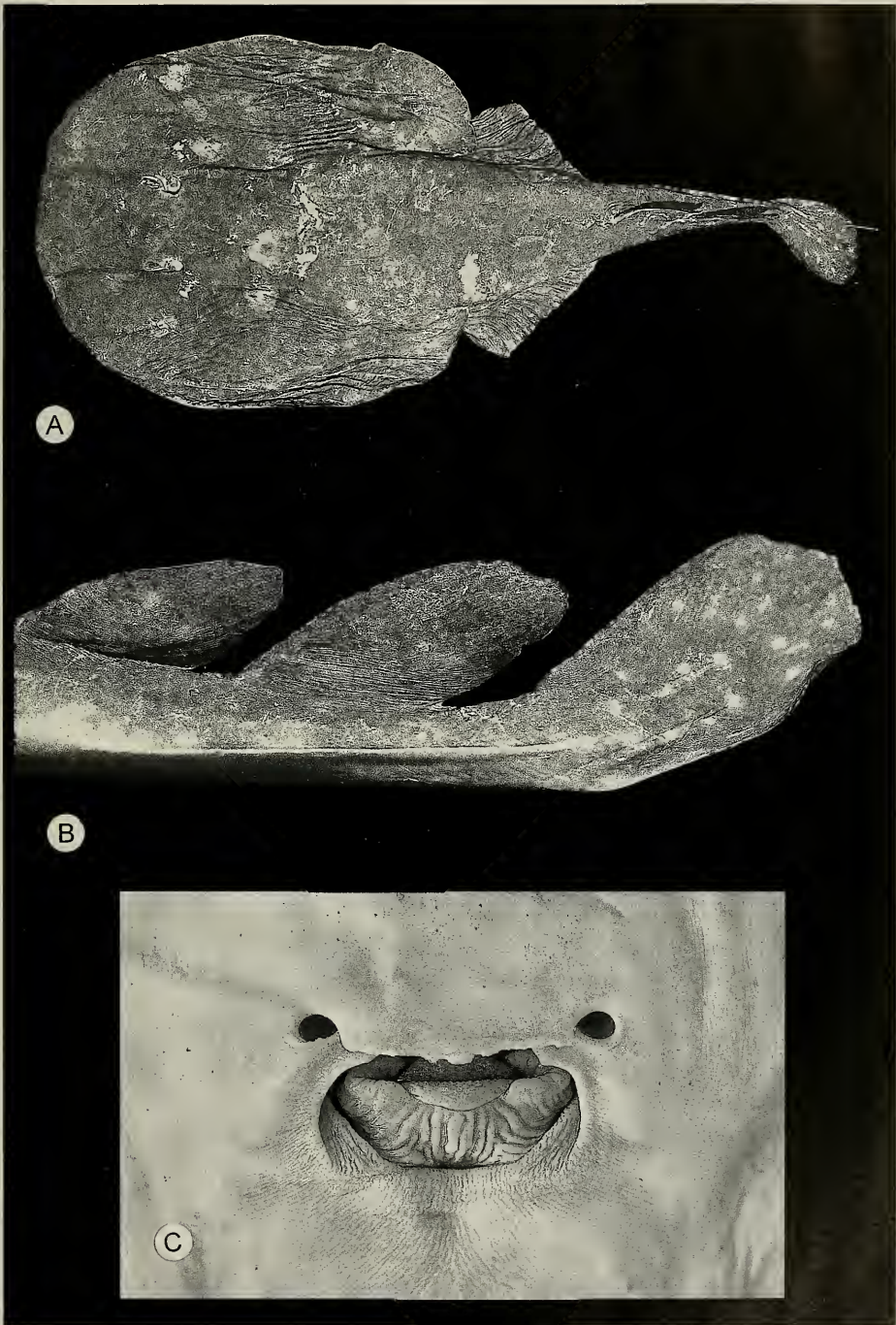


Fig. 3. A) Dorsal view of paratype of *Narcine leoparda*, n. sp. (USNM 222498, 272 mm TL adult female, from south of Buenaventura, Colombia, 02°56'N, 078°07'W, 0–16.6 m); B) lateral tail region of USNM 222498; C) nasoral region of USNM 222498. Note that caudal fin is downturned in (A).

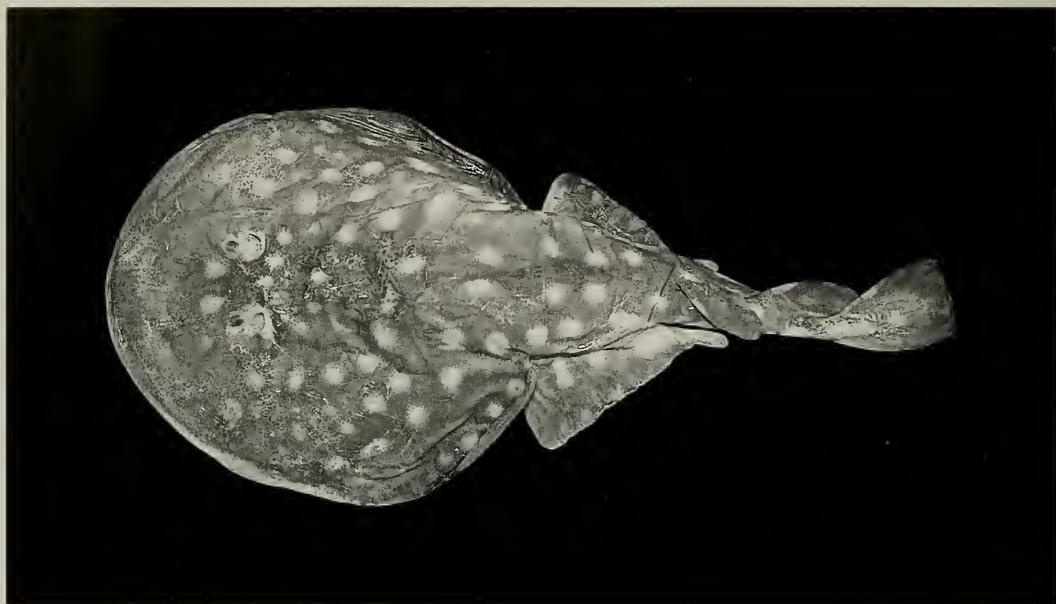


Fig. 4. Paratype of *Narcine leoparda*, n. sp. (USNM 222198, 174 mm TL male, south of Buenaventura, Colombia, 03°14'N, 077°33'W, 5–7 m).

processes are also present anteriorly adjacent to the rostral fenestra of neurocranium, providing further endoskeletal support to anterior margin of snout. Dorso-lateral projections of the nasal capsules (“nasal capsule horns” of Carvalho 1999a) are also present. One pair of triangular labial cartilages on each side of jaw symphysis give support to “lips” surrounding external tooth bands. Propterygium is subdivided into four segments; mesopterygium is small, slender and antero-laterally directed, and the metapterygium is subdivided and inconspicuous. Pelvic girdle with two pre-pelvic processes with expanded, flattened tips, and posteriorly curved iliac processes.

Etymology.—*leoparda*, modified from leopardus (Latin for leopard), in reference to its distinctive dorsal color pattern; interpreted as a feminine noun.

Geographical distribution.—*Narcine leoparda* is known from four localities on the continental shelf of Colombia, south of Buenaventura and Tumaco (off Punta Manglares), in near-shore waters ranging from 5 to 33 m in depth.

Discussion

Comparisons with congeners.—Only two other valid species of *Narcine* occur in the eastern Pacific Ocean: *N. entemedor* and *N. vermiculatus*. Among these, *N. leoparda* is most similar to *N. vermiculatus* Breder, 1928, which occurs farther north along the continental shelf of Central America (reaching as far south as Costa Rica; McEachran 1995, Carvalho 1999a). Both species are clearly distinct in dorsal color pattern. *Narcine leoparda* possesses white to creamy-white spots that may be substituted by ocelli in larger specimens, with spots not fused into larger blotches or vermiculations, as in *N. vermiculatus*, and generally smaller than the markings present in the latter species. The spots in *Narcine leoparda* are present even on newly born individuals or pups extracted from uteri (USNM 222198). Newly born specimens of *N. vermiculatus*, however, clearly display laterally elongated blotches or stripes and vermiculations that are characteristic of this species (e.g., Beebe & Tee-Van 1941, fig. 1, pl. 1; Carvalho

1999a). In *N. leoparda*, the spots may be lost in larger specimens, as USNM 222500 and USNM 222498 have more uniform dorsal coloration without clearly defined spots over disc. However, small white or creamy-white spots are still present over dorsal and caudal fins, and closer inspection reveals that both specimens previously had dorsal spots over the disc as well. *Narcine leoparda* also differs from *N. vermiculatus* in having lateral tail folds that begin underneath first dorsal fin base (either at its mid-length or slightly farther posteriorly), and not in between the dorsal fins. Other differences that further separate both species are disc proportions. Disc is generally more rounded in *Narcine leoparda*, with a greater mean disc length (53.4% of TL), compared to *N. vermiculatus* (48.4% of TL), which is also reflected in relative origin of first dorsal fin (originating farther posteriorly in *Narcine leoparda* [mean distance between snout and first dorsal origin is 68.0% of TL; compared to 64.1% of TL for *N. vermiculatus*]). Both species also have disjunct, allopatric distributions, as *N. vermiculatus* has not been collected south of Costa Rica.

Narcine leoparda is easily distinguished from *N. entemedor*, with which it co-occurs, in presenting spiracles devoid of papillae, in morphometric proportions, size of adults and coloration (data for *N. entemedor* from Carvalho 1999a). *Narcine entemedor* generally has an olivaceous brown background color, usually with dark blotches on disc of larger specimens, and symmetrically arranged ocelli in smaller specimens. These ocelli, however, are very different from those present in the holotype of *N. leoparda* in both color and arrangement (ocelli in *N. entemedor* have dark center and are fewer in number, as only four or five are usually present on disc). *N. entemedor* is a much larger species (up to 750 mm TL) compared to *N. leoparda* (largest specimen is 356 mm TL). Males of *N. entemedor* become sexually mature only between 340 and 370 mm TL (cf. to 180 mm TL for *N. leoparda*, see below). Numerous specimens of *N. ente-*

medor, and of *N. vermiculatus*, have been thoroughly examined from throughout their respective ranges, and are further described in Carvalho (1999a).

Narcine leoparda is easily distinguished from most other species of *Narcine* in morphometric proportions (20 species of *Narcine* are recognized as valid in Carvalho 1999a). In *N. leoparda*, tail length (as measured from cloaca) is subequal to, and generally less than, disc width or length, but tail length is much greater than the disc in the five Australian species of *Narcine* (*N. tasmaniensis*, *N. westraliensis* and three undescribed species) and in *N. rierai* from the western Indian Ocean. Both upper and lower tooth bands are broadly rounded and of subequal width in *N. leoparda*, contrasting to two southeast Asian species (*N. breviliata* and an undescribed species) in which the tooth bands are roughly triangular in shape, and in which the upper tooth band is much wider than the lower. In *N. leoparda*, the second dorsal fin is subequal to, or slightly greater than, the first dorsal fin in height and length of base, separating it from two undescribed western and northern Indian Oceans forms, in which the first dorsal fin is greater than the second. Both western Atlantic species (*N. bancroftii* and *N. brasiliensis*) also have spiracles with numerous papillae, as in *N. entemedor*, and are therefore easily distinguished from *N. leoparda*. The remaining five species of *Narcine* (*N. timlei*, *N. maculata*, *N. lingula* and two undescribed species from the northern Indian Ocean and Indonesia) are distinct from *N. leoparda* in coloration, as they have either elaborate dorsal patterns composed of brown spots and/or blotches over a lighter background, or a uniform coloration (*N. timlei*).

Biological notes.—One partially dissected female of 277 mm TL (holotype, USNM 222200) had a large egg mass in the right uterus, while a female of 200 mm TL (USNM 222198) contained two small late-term pups in the left uterus. Both pups are female, just slightly over 50 mm TL, and

the smallest one still has remnants of a yolk-stalk. No external gill-filaments or external teeth are present, but few internal teeth with small cusps can be observed. Both specimens were probably very close to birth. One small male of 127 mm TL still has a fading yolk-scar and claspers that do not project beyond the distal tips of pelvic fins. Males probably mature at around 180 mm TL, as a 174 mm TL male has claspers almost completely firm. There are 10 spiral valve turns in the intestine of at least one specimen examined (USNM 222198, cleared and stained). Small, unidentified ctenoid scales were present in the mouths of two specimens (USNM 222500 and USNM 222199, 168 mm TL), and therefore *N. leoparda* feeds also on fishes as do other species of the genus.

Key to the Eastern Pacific species of *Narcine*

- 1a. Spiracles with papillae present on outer rim *N. entemedor*
- 1b. Spiracles devoid of any papillae 2
- 2a. Dorsal coloration composed of horizontally elongated, white or creamy-white stripes and blotches *N. vermiculatus*
- 2b. Dorsal coloration with small white or creamy-white spots and/or ocelli, or relatively uniform in larger specimens with perhaps few spots over dorsal and caudal fins, but never with horizontally elongated stripes and blotches *N. leoparda*

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